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THE RATE AND PERIOD OF GROWTH OF POLYPORUS LUCIDUS *

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Very little has been done by botanists in regard to rate and period of growth among members of the higher groups of fungi. Miss Douglas (2) in 1906 studied the growth of *Panaeolus retirugis*, one of the agarics, under greenhouse conditions. Schmitz (4) in 1842 worked on a number of forms, both agarics and *Polypori*. Fries (3) had made the statement that fungi grow from the center outwards. Schmitz took exception to this, and by marking spaces of known size on such forms as *Polystictus hirsutus* and others, he was able to show that the growth was in the periphery and not the center. Beyond these, the literature relating to the growth of the higher fungi is very scanty.

It was to find out as much as possible concerning the phenomena of growth in these forms, especially the woody members, that this study was undertaken. Little was known definitely concerning the rate of growth, the growing period, the effects of external conditions, or for that matter even the actual position of the growing area. In some perennial forms, such as *Fomes fomentarius* and others in which a layer is added each year, it is an easy matter to obtain the yearly increase. But in these, the growth is so slow that it is impossible to obtain reliable data on the other points just mentioned. A form growing in abundance around Ithaca, N. Y., that seemed to be very well adapted for such a study was the so-called *Polyporus lucidus* (Leys.) Fr.† Its

* Contribution from the Department of Botany, Cornell University, No. 120.

† This is the name by which the fungus is commonly known in this country. However it has recently been described by Dr. Murrill in Bull. Torrey Club 29: 601. 1902, as a new species, *Ganoderma Tsugae*.

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growth is extremely rapid for one of these firm fungi, and consequently any change of any kind in growth that might occur would be easily noticed. The fungus, as was mentioned above, is a common one in the vicinity of Ithaca, sometimes found in large numbers in damp woods and gorges on dead stumps and trunks of hemlocks. It is one of the stalked *Polypori*, characterized by the red varnished appearance of the stalk and pileus. At maturity, which is always in the first year, it being an annual at least in the north, it becomes very hard and brittle.

Growth in this form begins early in the spring, it being one of the first to start. The fungus breaks through the outer layers of wood and bark and makes its appearance as a soft white round button or ball of mycelium some time in May or early June, though the date is somewhat dependent on external conditions. This button is at first nearly spherical, perhaps a centimeter or less in diameter. As to color, it is perfectly white, being as yet without a trace of the red varnish which characterizes its later stages. It is not until the plant has reached a length of one and a half to two centimeters that it begins to take on the varnished character. The varnish forms on the older parts of the plant, the young growing part always remaining white. This is characteristic of the plant through its entire development. It has a white zone of growing tissue at the margin, while the basal older parts are covered with the varnish. After a part assumes this condition, it is incapable of further growth. A number of buttons were noticed, which, probably on account of unfavorable weather conditions, had ceased to grow and had become covered with the varnish. Although these were not more than one centimeter in diameter, they remained unchanged the whole season.

The growing period is confined to the spring and early summer months. It rarely extends to the first of August, though perhaps under favorable conditions it may grow for a longer period, and generally stops by the middle of July. The growth takes place at the extreme edge of the fungus. It is the result of adding more tissue to the outside, or in other words it is exogenous. After a part or zone is once formed, it is incapable of further growth. No matter how close to the margin a mark was placed, all the growth was outside of it. For instance, spaces one millimeter apart were marked on the pileus with India ink. On examination a few days later, it was seen that all the growth had taken place in the outer millimeter. The other spaces had not increased in size.

This manner of growth is unusual in other families of the plant kingdom. In all higher plants, the zone of growth is located a little distance back from the apex of the growing point. Also in the agarics among the fungi, we find a method similar to the higher plants in the elongation of the stipe. According to Miss Douglas and also Schmitz, the most rapid growth is in a zone slightly below the apex of the stem, and from this zone, growth is less marked as the base of the stem is approached. But the stems of the agaric and of the polypore seem to be different and are not comparable from the standpoint of growth. In the agaric, the hymenium is formed and the growth of the stem merely raises this up above the ground where the wind may catch the falling spores. In *Polyporus lucidus*, the stem is the first part formed and is perfectly developed before the hymenial surface starts to form under the pileus. If we are to compare the growth in the two forms, we should compare it in the young pilei in both cases before and while the hymenium is forming. In the agaric, this will exclude the elongation of the stipe, while in the *Polyporus*, it will include nearly the whole development of the plant. Whether the growth and development of any of the agarics is similar to the method we have seen in *Polyporus lucidus* is a question. It is surely not in all cases for Atkinson (1) has shown that in *Agaricus campestris*, there is an endogenous development in the pileus in the early stages. The latter is very different from the exogenous development in *Polyporus lucidus*. Other forms of agarics as *Collybia* and *Cantherellus* that have an exogenous development of the hymenium may have a growth similar to *Polyporus lucidus*, but this can be answered only by observation and measurement.

Among the external conditions which may affect growth are temperature, moisture, and nourishment. Temperature has a decided influence. A long cold period will cause almost a total stopping of growth, though the fungus responds very quickly again to warmth. The effect of temperature will be very clearly shown in FIGURE I. Curve B represents the average growth of twenty fungi from June 7 to June 24, while curve A shows the average daily temperature for the same period, the figures for this being obtained from the local weather-bureau office. As will be seen, the temperature curve contains a decided depression from June 10 to June 13, showing a cold period. The average temperature ranged from 49° to 56° F. during this period, while during the rest of the time it was between 65° and 76°. The effects of this cold period are clearly shown in the lower curve. Growth

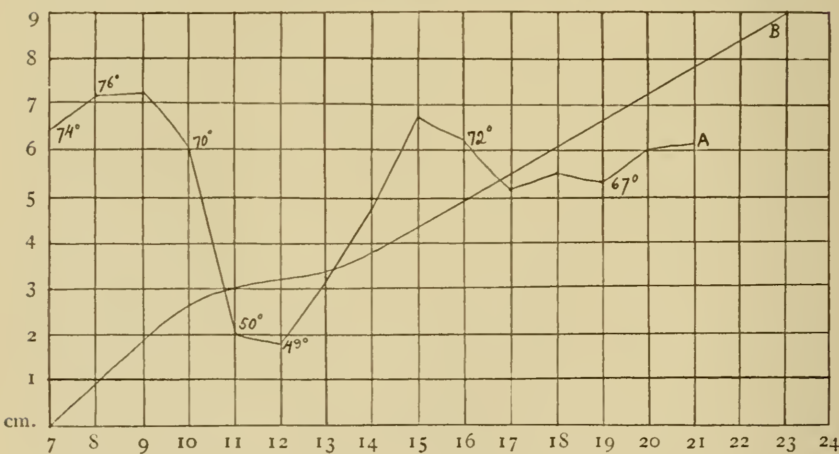

FIGURE I. Curve A represents the average daily temperature from June 7 to June 21, 1906, showing a cold period from June 10 to June 13.

Curve B represents the average daily growth of twenty specimens of *Polyporus lucidus* during the same period. The effect of temperature on growth is shown.

was almost at a standstill. Some individual fungi did go through this period of three days without a measurable increase in growth.

As to moisture and nourishment, we are unable to form an accurate conception of their influence. The fungus grows on logs and stumps which hold a large amount of moisture for some time. It is hardly probable that the lack of moisture is a factor until the logs begin to dry out in the summer. It may then, and probably does, have something to do with the stopping of growth at that time. The question of nourishment was not studied, it being impossible to determine the variation in nourishment if there was any.

From the button stage until the plant almost reaches maturity, growth is at a very even rate, as will be seen in the curve in FIGURE 2. Of course the individual fungi vary some, but the average of a number gives almost a straight line. There is an evident depression in the curve, but this is not due to a normal decrease in growth at this period, but due to the period of low temperature above discussed. Of course in making the curve, it was neces-

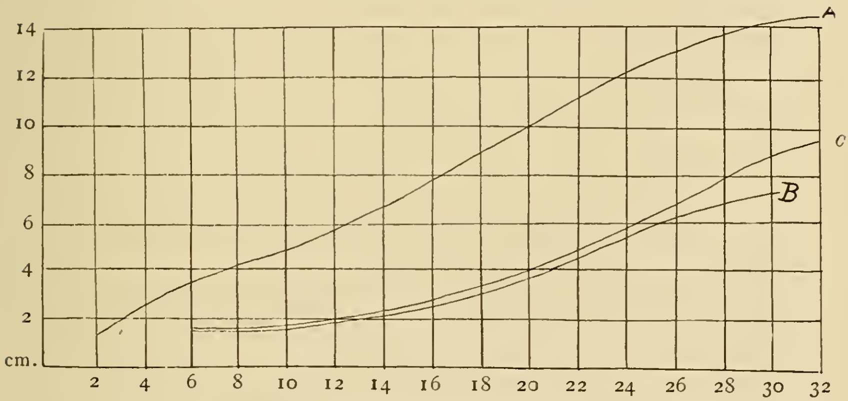

FIGURE 2. A represents the average daily growth of a number of individuals from the button stage to maturity, during a period of thirty-two days. Growth is figured in centimeters.

B represents the increase in length of the white area underneath the pileus, during the same period.

C represents the lateral growth of the pileus during the same period.

sary to start all the fungi of a certain size at a certain place on the curve, for instance all the fungi about 1.2 cm. in length were started at 2 on the curve, whether they began to develop at the same time or three weeks apart. From this point, the curve was plotted, the average daily increment of growth being used for the ordinates and the number of days for the abscissæ. In all of the fungi measured, the cold period came sometime between the seventh and seventeenth days of their development. And as will be seen, that period shows the depression in the curve. Measurements were not taken on the young buttons until they were about two days old. A number at this age averaged 1.2 cm. in length.

The average growth of this fungus is about one half-centimeter per day. Individual plants sometimes grow as much as a centimeter per day, but this is not common. Compared to other woody forms, a half-centimeter per day is very rapid growth. Most of these are perennial, and the total yearly growth is only a few centimeters at the most. Probably the fastest growing perennial form that we have is the so-called "*Polyporus applanatus*." * Yet from measurements taken during the summer, the fastest growth for any individual was 1.5 mm. per day, while the average growth for a number during the month of August, that being the month in which growth is the most rapid, was 0.7 mm. per day. This is only one seventh as fast as that of *Polyporus lucidus*. Compared to slower growing forms as *Fomes fomentarius* and *Fomes pinicola*, the difference must be much greater.

This extremely rapid growth means a large amount of added tissue each day. The fungus is about one half-centimeter thick at the apex. Taking one that is only twenty-five centimeters in length, we would have added a daily increment of twenty to twenty-five cubic centimeters. This must mean a very rapid utilization and transport of the food materials by the fungus.

As the plant approaches maturity, growth gradually ceases and for the last week or ten days it is very slow. External factors seem to be the cause of the maturing of the plant. For the curve last mentioned, plants were used that came to maturity at a length of about fourteen to fifteen centimeters. If plants had been used that matured at twenty-five centimeters, the only difference in the curve would have been the lengthening of the straight part of it until a height of about twenty-three or twenty-four was reached. The plant seems to be able to keep growing at about the same rate as long as conditions are right. But when conditions are not right, as for instance, lack of moisture or nourishment, the plant takes on the mature condition.

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* *Fomes megaloma* Lév., or according to Murrill in Bull. Torrey Club **30**: 300. 1903, *Elfvingia megaloma* (Lév.) Murrill.

This is also shown by the fact that quite generally all the plants on a single stump, both large and small, will come to maturity at the same time.

As we have noticed before, *Polyporus lucidus* is one of the stalked *Polypori*, but the length of the stalk is variable with the different plants, some being nearly sessile, while others have very long stalks. The stalk is the first part of the plant to develop. From the button stage, the plant continues to add on more tissue exogenously, all of which becomes covered with the red varnish except about one to two centimeters of the terminal margin, which remains white. However, after the plant has been growing for seven to fifteen days, it will be noticed that the white part on the under side of the plant is becoming longer. It does not become varnished over as fast as it is formed. Or, in other words, the pileus has commenced to form. This is rather a slow process at first, as the cap does not seem to be started all at once, but the varnishing process on the under side gradually slackens up. Consequently as the plant develops, there is left a greater white area beneath. This white area is used in the curve representing the development of the pileus. This area does not all develop into pileus, for that of the first few days of development becomes part of the stalk. It is impossible to tell how much of this white area will be stalk and how much pileus until several days after it begins to increase in size. Then the boundaries of the cap or the hymenial surface become marked out, and consequently thereafter, the increase of the cap equals that of the whole plant. The formation of the pileus does not begin at the same time with all plants, so it is a difficult matter to show its development with a curve. But this was attempted by selecting a number of plants having about the same length of stalk, about six centimeters, and plotting the average increase of the white area on the under side of the pileus. This shows that in plants with stalks of this size, the stalk reaches its complete development between the twelfth and eighteenth days, and also that the boundary of the cap is established between these dates. Of course with a longer or shorter stalk this would vary somewhat. But the curve shows the most important fact, that the formation of the pileus is a gradual process.

About the time the pileus begins to form the plant begins to widen out. Up to this time, the increase by growth had been almost entirely in length. In the increase in width, we find considerable variation, more so than in the increase in length. But the average of a number of plants shows that the lateral growth is but very little faster than the terminal growth. In the increase in width, there are of course two growing zones, both sides adding an equal amount of tissue. Consequently the growth on one side is but slightly over one half what it is on the terminal margin. As a result, the hymenial surface of the mature plant is generally but slightly wider than it is long. Of course, we sometimes find very wide plants but these are quite often due to the fusing together of several small caps that started from the same stalk. Curve C in FIGURE 2 is plotted showing the increase in width, the values being obtained from the average growth of a number of individuals. The curve brings out the facts above mentioned. It is strikingly similar to the one showing increase in length of the pileus. Yet we have two sides increasing in width to only one increasing in length.

In conclusion, we will merely enumerate the results already mentioned: (1) *Polyporus lucidus* is a fast growing member of the Polyporaceae, growth averaging about one half-centimeter per day for the growing period. (2) Growth is exogenous, taking place entirely at the edge of the plant and continuing as long as conditions are favorable. (3) The change in the development from stalk to pileus is a gradual process. (4) The average lateral growth is but slightly more than the terminal growth.

In closing, I wish to acknowledge my indebtedness to Professor Atkinson, at whose suggestion this work was undertaken and carried out.

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OUR EASTERN SHADWOODS

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The genus *Amelanchier* is interesting to many people, and botanists are but a small part of them. The flowers are early and showy and the fruit is early and quite edible. Throughout most parts of the north temperate zone some form of it occurs, often more than one, and all are much alike. They may be treated as forms of a single species as Michaux, and Torrey and Gray treated our North American forms.

All of the forms of this genus readily and probably naturally fall into two classes. The type of one class is our *A. canadensis* (L.) Medic. This class is characterized by serrate acuminate leaves varying from cordate to cuneate, and naked-topped fruit. It includes *A. asiatica*, *A. oblongifolia* (T. & G.) Roem. and *A. oligocarpa* (Michx.) Roem. The last-named may be made a subclass.

The type of the other class is the European *A. rotundifolia* (Lamarck) Dum.-Cours, synonyms of which are *A. vulgaris*, *A. ovalis* Medic. (1793) and *A. Amelanchier*. This second class is characterized by oblong or rounded leaves, generally dentate and often thick, and woolly-topped fruit. It includes Michaux's *Mespilus canadensis* var. *rotundifolia*, Lamarck's *Crataegus spicata*, Spach's *A. ovalis*, and Nuttall's *A. alnifolia* and the large number of species lately segregated from *A. alnifolia* in the "Far West." All of the characters of these two classes though pretty constant are not always so.

To decide on the names by which the forms shall be called is not a simple matter. They have been described as species and varieties under several generic names, the best known being *Mespilus*, *Crataegus*, *Pyrus*, *Aronia*, and *Amelanchier*, and have often